CLAIMS:

1. An evanescent wave cavity-based optical sensor, the sensor comprising:

an optical cavity formed by a pair of highly reflective surfaces such that light within said cavity makes a plurality of passes between said surfaces, an optical path between said surfaces including a reflection from a totally internally reflecting (TIR) surface, said reflection from said TIR surface generating an evanescent wave to provide a sensing function;

a light source to inject a pulse of light into said cavity;

a detector to detect decaying oscillations of said light pulse within said cavity; and

a signal processor coupled to said detector and configured to provide a time-resolved output responsive to a light level within said cavity and having a time-resolution corresponding to a set of said light pulse oscillations, whereby said sensing function operates at substantially said time-resolution.

2. An optical sensor as claimed in claim 1 wherein said set of light pulse oscillations comprises a single said light pulse or a pair of said pulses.

3. An optical sensor as claimed in claim 1 or 2 wherein said TIR surface is provided with a functionalising material over at least part of said TIR surface such that said evanescent wave interacts with said material;

whereby an interaction between said functionalising material and a target to be sensed is detectable as a change in absorption of said evanescent wave.

4. An optical sensor as claimed in claim 1 or 2 wherein said TIR surface is provided with an electrically conducting material over at least part of said TIR surface such that said evanescent wave excites a surface plasmon within said material;

whereby a change in absorption of said evanescent wave due to a change in said surface plasmon excitation is detectable using said detector to provide said sensing function.

5. An optical sensor as claimed in any preceding claim wherein said optical cavity comprises a fibre optic sensor configured to provide an evanescent field from light guided within the fibre.

6. An optical sensor as claimed in any preceding claim wherein said time-resolution is substantially determined by a length of said optical cavity.

7. A method of performing time-resolved sensing using an optical cavity including a sensing surface, a sensing interaction at said sensing surface modifying an optical ring-down characteristic of said cavity, the method comprising:

injecting a pulse of light into said cavity; and

monitoring an optical ring-down of said pulse within said cavity to monitor said sensing interaction; and

wherein said monitoring is performed substantially on a pulse-by-pulse basis such that said sensing is time-resolved at a resolution of at least an integral number of round trip times of said cavity.

8. A method as claimed in claim 7 wherein said integral number of round trip times is one.

9. A method as claimed in claim 7 or 8 further comprising selecting said time resolution by selecting a length of said cavity.

10. An evanescent-wave cavity-based optical sensor system, the system comprising:

an optical cavity formed by a pair of highly reflective surfaces such that light within said cavity makes a plurality of passes between said surfaces, an optical path between said surfaces including a reflection from one or more totally internally reflecting (TIR) surfaces, a said reflection from a TIR surface generating an evanescent wave to provide an attenuated TIR sensing function;

a light source to optically excite said cavity at at least two different wavelengths; and

a detector to monitor a ring-down characteristic of said cavity at each of said two wavelengths; and

wherein said one or more TIR surfaces are provided with at least two functionalising materials one responsive at each of said wavelengths such that an interaction between a said functionalising material and one or more targets to be sensed is detectable as a change in absorption of a said evanescent wave at a said wavelength.

11. A sensor system as claimed in claim 10 wherein said two functionalising materials comprise different materials selected to detect a common said target.

12. A sensor system as claimed in claim 11 further comprising a signal processor coupled to said detector and configured to provide an output signal indicative of said target from a combination of said ring-down characteristic at said two wavelengths.

13. A sensor system as claimed in claim 11 or 12 wherein a said TIR surface is provided with both said functionalising materials.

14. A sensor system as claimed in claim 11 or 12 wherein said optical cavity includes at least two said TIR surfaces, and wherein a first of said TIR surfaces is provided with a first of said functionalising materials and a second of said TIR surfaces is provided with a second of said functionalising materials.

15. A sensor system as claimed in any one of claims 10 to 14 wherein said optical cavity includes a fibre optic configured to provide said one or more TIR surfaces.

16. A sensor system as claimed in any one of claims 10 to 15 wherein said cavity has a length of at least 5 metres, 10 metres, or 50 metres.

17. A method of wavelength division multiplexing sensors of an evanescent wave cavity ring-down sensor system, the method comprising:

applying a plurality of different functionalising materials to one or more evanescent wave sensing regions of a cavity of said sensor system, said different functionalising materials having sensing responses at different wavelengths;

exciting said cavity at a plurality of different wavelengths corresponding to wavelengths of said sensing responses of said functionalising materials; and

monitoring a ring-down characteristic of said cavity at each of said exciting wavelengths.

18. A waveguide-based cavity ring-down sensor for sensing an environmental variable, the sensor comprising:

an optical cavity including a waveguide;

a light source for exciting the optical cavity; and

a detector for monitoring a ring-down characteristic of the cavity; and

a signal processor coupled to said detector and configured to provide a signal output responsive to a change in optical propagation loss within said cavity as determined from said ring-down characteristic; and

wherein a change in said environmental variable causes a change in optical propagation loss in said waveguide to provide said signal output.

19. A sensor as claimed in claim 18 wherein said waveguide comprises a fibre optic.

20. A fibre optic sensor as claimed in claim 18 or 19 wherein said waveguide is doped to respond to said environmental variable.

21. A sensor as claimed in claim 18, 19 or 20 wherein said environmental variable comprises one or more of temperature, magnetic field strength, and electric field strength.

22. A sensor as claimed in claim 21 wherein said waveguide is doped with a paramagnetic material, and wherein said environmental variable comprises magnetic field strength.

23. A sensor as claimed in any one of claims 18 to 22 wherein said light source is configured to excite said cavity at two different wavelengths simultaneously, wherein said detector is configured to monitor ring-down characteristics of said cavity at said two different wavelengths, and wherein said signal processor is configured to provide said signal output responsive to said ring-down characteristics at said two different wavelengths.

24. A sensor as claimed in claim 23 when dependent upon claim 20 wherein said waveguide is doped with Erbium, wherein said environmental variable comprises temperature, and wherein said wavelengths are selected such that said ring-down characteristics at said two different wavelengths vary in opposite senses with a change in said temperature.

25. A waveguide-based sensing method for sensing an environmental variable using an optical cavity including a waveguide, the method comprising:

determining an optical ring-up or ring-down time for the cavity to determine a cavity loss; and

determining a change in said cavity loss from a change in said ring-up or ring-down time, said change in loss being caused by an effect of a change in said environmental variable on said waveguide, to sense said change in said environmental variable.

26. A method as claimed in claim 25 wherein said waveguide is doped.

27. A method as claimed in claim 25 or 26 further comprising determining said ring-up or ring-down time at two wavelengths, and determining said change in cavity loss at said two wavelengths to determine a change in said environmental variable.

28. A method as claimed in claim 25, 26 or 27 wherein said environmental variable comprises one or more of temperature, magnetic field, and electric field.

29. Fibre optic system characterising apparatus for characterising a fibre optic system using optical ring-down, the apparatus comprising:

an optical cavity configurable to include said fibre optic system;

a light source for exciting said cavity;

a detector for monitoring an optical ring-down of said cavity; and

a signal processor coupled to said detector and configured to determine a characteristic of said fibre optic system from said cavity optical ring-down.

30. Fibre optic system characterising apparatus as claimed in claim 29 wherein said fibre optic system comprises a fibre optic cable.

31. Fibre optic system characterising apparatus as claimed in claim 30 wherein at least one end of said fibre optic cable is provided with a mirror coating to form at least one end of said optical cavity.

32. Fibre optic system characterising apparatus as claimed in claim 31 wherein both ends of said fibre optic cable are provided with a mirror coating to form said optical cavity.

33. Fibre optic system characterising apparatus as claimed in any one of claims 29 to 32 wherein said fibre optic system characteristic comprises a transmission loss.

34. Fibre optic system characterising apparatus as claimed in any one of claims 29 to 33 wherein said fibre optic system characteristic comprises a measure of dispersion in the fibre optic system.

35. Fibre optic system characterising apparatus as claimed in any one of claims 29 to 34 wherein said signal processor comprises a computer system including a processor and program memory, the program memory storing instructions to control the processor to input light level values from said detector, to determine a ring-down time for said cavity including said fibre optic system from said light level values, and to determine said fibre optic system characteristic using said ring-down time.

36. A carrier carrying the processor control instructions of claim 35.

37. A method of characterising a fibre optic system using optical ring-down, the method comprising:
forming an optical cavity including said fibre optic system;
exciting said optical cavity using a light source;
monitoring a ring-down of said cavity following said excitation; and
determining a characteristic of said fibre optic system from said monitoring.

38. A method as claimed in claim 32 wherein said fibre optic system comprises a fibre optic cable.

39. A method as claimed in claim 38 wherein said characteristic comprises a transmission loss.

40. A method as claimed in claim 39 wherein said characterising comprises characterising a fibre manipulation loss, and wherein said optical cavity forming includes performing a manipulation on said fibre optic cable.

41. A method as claimed in claim 11 wherein said manipulation comprises bending or tapering said fibre optic cable.

42. A method as claimed in claim 9 or 10 wherein said characteristic comprises a measure of dispersion in said fibre optic system.

43. A method as claimed in any one of claims 37 to 42 wherein said monitoring comprises monitoring at a plurality of wavelengths simultaneously.

44. A fibre optic sensor, the sensor comprising:
an optical cavity including a fibre optic;
a light source for exciting the optical cavity; and
a detector for monitoring a ring-down characteristic of the cavity; and
wherein said fibre optic is configured such that a change in a sensed variable causes a physical change in said fibre optic configuration modifying said ring-down characteristic.

45. A fibre optic sensor as claimed in claim 44 wherein said fibre optic configuration includes one or more bends.

46. A fibre optic sensor as claimed in claim 44 or 45 wherein said fibre optic is mounted on a pressure-responsive support structure to sense pressure.

47. A fibre optic sensor as claimed in claim 44 or 45 wherein said physical change in fibre optic configuration comprises a change in length of said fibre optic.

48. A fibre optic sensor as claimed in claim 47 wherein said change in length causes a distortion of said fibre optic.

49. A fibre optic sensor as claimed in claim 47 or 48 wherein said fibre optic sensor is configured to sense one or more of stress, strain and temperature.

50. A fibre optic sensor as claimed in any one of claims 44 to 49 further comprising a signal processor coupled to said detector and configured to provide a sensed variable output by determining a ring-down time of said cavity.

51. A fibre optic sensor as claimed in claim 50 configured to provide said sensed variable output responsive to signals sensed simultaneously at a plurality of wavelengths.

52. A method of sensing using distortion of a fibre optic, the fibre optic comprising at least part of an optical cavity, the method comprising:

determining an optical ring-up or ring-down time of said cavity;
distorting said fibre optic with a sensed variable; and
determining a change in said ring-up or ring-down time to sense said distortion.

53. A method as claimed in claim 52 wherein said fibre optic is bent.

54. A method as claimed in claim 52 or 53 wherein said distorting includes changing a length of said fibre optic.

55. A method as claimed in claim 52, 53 or 54 wherein said sensed variable comprises one or more of temperature, pressure, stress and strain.

55. An evanescent-wave cavity-ring down sensing system, the system comprising:

an evanescent-wave optical cavity;
an optical pump to provide a pump pulse to said optical cavity at a first wavelength; and
an optical probe to provide a probe pulse to said optical cavity at a second wavelength.

56. A sensing system as claimed in claim 55 comprising at least one pulsed illumination source to provide said pump and probe pulses.

57. A sensing system as claimed in claim 56 wherein at least one of said pump pulse and said probe pulse is shorter than an optical round trip time of said cavity.

58. A sensing system as claimed in claim 55, 56 or 57 wherein a loss of said optical cavity at said first wavelength is such that said pump pulse makes substantially only a single pass of said optical cavity.